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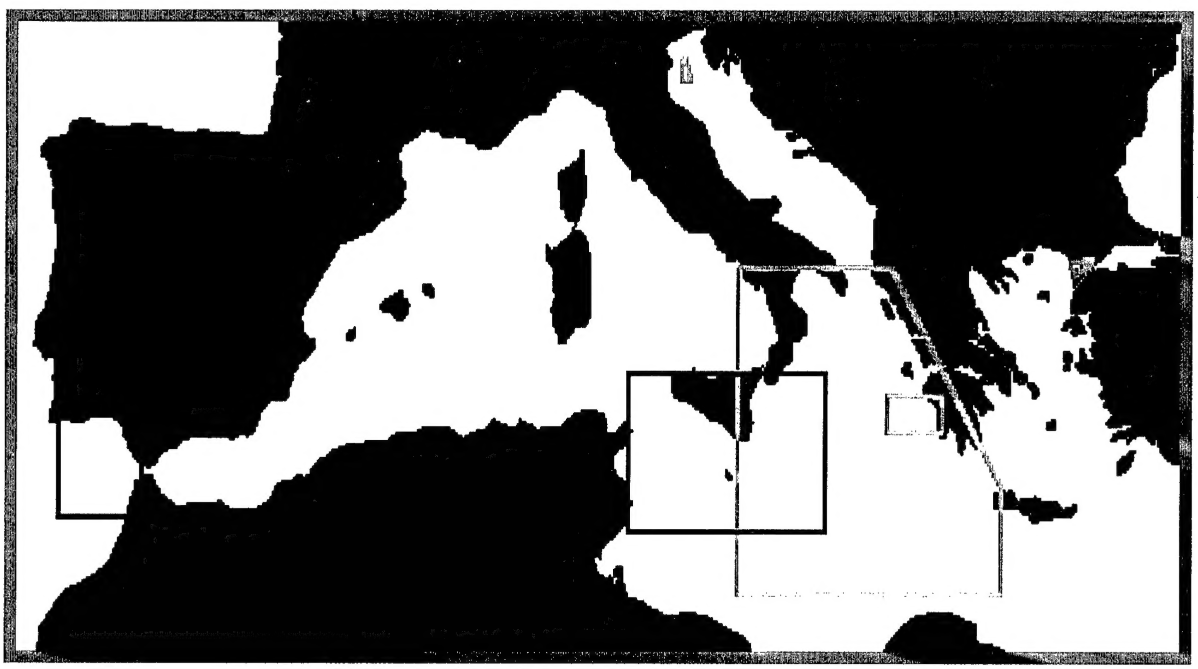

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Rapid environmental assessment for naval operations

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Jan L. Spoelstra
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Rapid environmental assessment for naval operations

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Executive Summary: Knowledge about the environment is a precondition for the choice of proper tactics and for the proper use of combat systems. Constant environmental parameters are often not known with sufficient accuracy. For available ocean parameters, a permanent observational network comparable with that for weather prediction does not exist. Rapid Environmental Assessment (REA) is a methodology for the closure of knowledge gaps and provision of useful environmental information in a tactically relevant time frame.

REA surveys must be planned and organized according to operational relevance of measurements, fast conversion into products and appropriate delivery to naval commanders. In order to meet these requirements, a certain organizational structure is required, fast data processing tools and modern data communication channels. Data and product accessibility is guaranteed by a data fusion centre, while data processing and product generation can be accomplished by distributed laboratories connected in an Internet-like network.

Concepts and procedures must be tested, trained and developed in REA exercises that may or may not be connected with military exercises. Specific instrumentation for REA is developed under the premise of immediate data availability. New scientific methods will reduce the time spent for data collection. The Rapid Response surveys are described as examples for extensive REA effort prior to naval exercises.

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Rapid environmental assessment for Naval Options

J. Sellschopp

Abstract: Rapid Environmental Assessment (REA) is a methodology that is being implemented in order to close knowledge gaps and to provide useful environmental information in a tactically relevant time frame. REA surveys are set up for operational needs rather than to give a full scientific picture. Emphasis is on an optimal organizational structure, fast data processing tools and modern data communication channels. Distributed data processing and product generation is complemented by a particular data fusion centre in an Internet-like network.

Specific instrumentation for REA is developed under the premise of immediate data availability. New scientific methods will reduce the time spent for data collection. Techniques, concepts and procedures must be tested, trained and developed in REA exercises that may or may not be connected with military exercises. The Rapid Response surveys are described as examples for extensive REA effort prior to naval exercises.

Keywords: environment – rapid environmental assessment – data fusion – exercise – military oceanography

Contents

1 Introduction

The phrase "rapid environmental assessment" is often misunderstood because it is too general to characterize the REA concept. As a simple example of a rapid assessment one might see dark clouds in the sky and judge that it will be raining soon, but this has nothing to do with an REA operation of the kind that we have in mind. This article intends to describe rapid environmental assessment (REA) as a modern approach and new methodology for support of navy operations. It is necessary to explain the REA concept by comparison with the current situation in environmental support for naval operations.

Weather forecasts, climatological atlases, tide tables, navigational handbooks, the NATO standard oceanographic data base and so on, are all standard sources of environmental knowledge. They are permanently available to navy staff, on navy ships or at least at environmental support centres, or they are regularly generated. For many years even satellite images of cloud cover and temperature radiation have been released to the public in almost real-time. The preparation, collection and delivery of all these standard products is normal environmental support. It does not fall under the definition of REA in the present context.

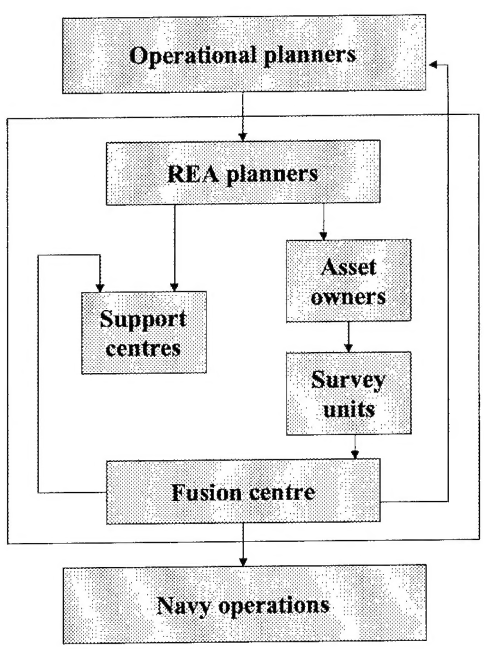
REA comes into play when a naval commander or combat planner needs environmental information that is not available at his oceanographic support centre. He will then ask for the acquisition of the necessary data and preparation of an appropriate environmental product. NATO's responsible addressee in that case is the military oceanography (MILOC) group. Numerous ocean areas have been identified in the course of the last 30 years and surveys carried out for the acquisition of representative data and for a better understanding of oceanographic processes that are important in the specific regions. Nations provided military survey ships and research vessels with their crews and scientific teams. Contacts to commands and national authorities were held by a military coordinator. A chief scientist, usually provided by the NATO SACLANT Undersea Research Centre, was responsible for survey planning and direction, and for the delivery of a final environmental report that combined the results provided by participating laboratories. Usually excellent descriptions of the environment were obtained from MILOC surveys, but the whole process from data collection to the final report always took several years. Naval users became unhappy with traditional MILOC surveys, when the importance of an ocean area had changed between survey planning and the delivery of results. A requirement was formulated for operationally relevant 'products' provided within a tactically relevant time interval after identification of a particular area. The goal of REA is to meet this requirement.

Tactically relevant time scales range from several months in an early operational planning phase down to days during navy operations. Traditional survey data processing can

possibly be speeded up if it gets very high priority at the assigned laboratories. This would decrease product delivery times from years to months. In order to arrive at days between measurements and product delivery, new data processing and product generation methods are required together with new paths for the data flow. After these paths are established, REA offers more than just fast versions of traditional procedures. MILOC surveys of the old type have been appropriate for data base generation of non-changing environmental parameters such as sea bottom type or tidal constituents. Time varying parameters were acquired as well and used to augment statistical (climatological) databases. In the worst case of non-existent previous knowledge, measurements had to be regarded as representative for an area in an entire season. This assumption can be misleading. In contrast, fast channels and data processing tools developed for REA are ideal for the distribution of information that is valid for a limited time such as transient ocean circulation patterns or positions of non-stationary sand banks. Thus REA adds real-time environmental knowledge to databases or, in a broader sense, it adds 'weather' to 'climate'.

2
Components of a REA System

Naval operations planners activate REA operations (Fig. 1), when they are unable to obtain the necessary information through their usual channels. REA planners will then investigate the possibility of obtaining information from support centres that currently work on the problem or who already hold results that have been unknown to navy planners. Typical support centre candidates are national hydrographic services, navy labs, governmental and academic research institutes. In the case of a new measurement campaign being required the owners of appropriate platforms would be contacted and a survey plan developed. Patrol aircraft and ships are the traditional, but not the only possible platforms for MILOC surveys.



An environmental product required by military planners or operational commanders might be a combination and condensation of data from different providers. Consider, for example, how the prediction of surf at a beach, relies on input parameters from several sources. Ocean swell generated far from shore might be available from satellite measurements. For calculation of wave refraction, a good bathymetric chart might be provided by a hydrographic office. The beach slope that controls wave breaking can be obtained from depth measurements by an airborne laser. Finally, the wind conditions to be taken into account can come from an atmospheric forecast model. Similarly various REA products build on multiple data sources, some of which are required for several products.

Figure 1 *The flow of requirements, intermediate data and final environment products.*

To bring all necessary data to the required places, is a difficult task unless there is a single fusion centre for all providers. Here all providers and product developers can find the most recently acquired data and everybody else's products. Whilst REA planners represent the brain of the system, the fusion centre is the heart that maintains the flow of raw data and enriched information up to the final product through the network that connects all participants of REA.

During an REA operation, the amount of data is continuously growing. The fusion centre is responsible for all delivered contributions being accessible and easily found. Information can only be passed quickly between partners, if it is stored electronically rather than printed on paper. For data exchange between computers, cost-effective proprietary software solutions are strongly discouraged. Internet technology is the appropriate solution for an REA network; it is transferable to classified military networks. But also the Internet itself is capable of secure transmissions and of access restricted to authorized sites only. Internet technology is available everywhere at no extra cost and delays due to procurement and installation are avoided.

Unlike support centres, that must be able to select from the complete set of collected data, the final customers, operational planners and commanders of navy operations, usually prefer condensed products. The web server at the fusion centre provides both details and overviews. It guides the user *via* links to the desired piece of information. Information retrieval can be eased by constructing special warfighters' pages that point to pre-filtered subsets of data and products. The creation of pages offering only information relevant for a specific warfare area, has been called 'product fusion'. It is not essential to edit the warfighters' pages at the data fusion centre, but it should be done in close connection with the navy staff. Technically this is easily achieved in a web architecture, because the mechanism of links between computers in the network permits different groups to remain at different locations during their work on a common data set. In general, it is desirable that most products are already developed at support centres or at the data origin, so that the fusion centre can concentrate on data administration. As a rule, however, contributions should not only stay with the support centres but should be gathered on a single server at the fusion centre. The server's contents might be put on a CD-ROM, both for REA customers who do not have a good network connection, and for archiving.

The environmental product to be provided by REA very much depends on the various REA customers and their capabilities. A military commander who, in addition to his other duties, has to quickly assimilate the environmental conditions, needs very condensed information. Much more data should be provided for the military staff who has the expertise and manpower to draw conclusions from the variety of possibly even contradictory information. Therefore the military customer should be seen as part of the REA organization structure. He is obliged to define what he needs and what degree of complexity is required.

3
REA exercises

Practicing operational REA on the occasion of naval exercises is a good idea, but exercise artificiality imposes severe problems on REA planning and accomplishments. An REA planner asking a warfighter, what gaps in the knowledge of the exercise environment he would like to get filled, might get the answer that exercises have been carried out in the same area so many times, that everybody knows it inside out and needs no more than a weather forecast. According to the philosophy of operational REA, this answer would terminate REA planning. Because of the need for rehearsals, the REA planner may insist on asking what gaps in the knowledge of the exercise environment the warfighter would expect if the area were unknown to him. Even if the rephrased question is answered fairly, this would not help much because all previous knowledge will be recovered soon when archives are searched. Therefore it would seem that a realistic operational REA exercise could not be executed in a well known area, where naval exercises usually take place. This is, however, not the whole truth as will be explained.

Table 1 *Environmental parameters having impact on sound propagation*

Parameter	Prediction from	Availability
Background noise Shipping Surface waves, wind	 Climatology Weather forecast	 Area survey Standard
Volume attenuation Chemical properties Fish	 Tables Statistical description	 Standard Usually not available
Bottom attenuation	Atlases	Area survey
Bottom scatter	Atlases	Area survey
Surface scatter	Weather forecast	Standard
Sound velocity field Average profile Eddies, fronts Internal waves, intrusions Surface layer	 Climatology Deterministic models Statistical description Weather forecast	 Area survey Adaptive sampling Usually not available Standard

Taking environmental impact on sonar performance as an example (Table 1), we find many different time scales in the parameters controlling the decrease of sound intensity. During a naval operation, the parameters that depend on the actual weather situation should be observed by units at sea instead of being forecasted. High frequency noise and surface scattering react immediately to changes of wind and waves. The sound velocity gradient in the upper few metres of the ocean follows solar radiation and wind mixing on a time scale of hours. Sonar operators are aware of that mechanism and undertake sufficiently frequent observations. On the other hand, there are parameters that practically never change but depend on location, such as water depth and bottom material. If they are known already, there is no reason to survey them again. Between invariant and rapidly changing properties, there is the group of slowly varying parameters that might have been measured many times and filtered into results representing a "climate". Examples are monthly mean values of sound velocity as a function of depth, and low frequency noise from ships in an area. An actual situation can differ significantly from average climatology. A single measurement taken on site is often not representative for an area, but can be combined with other measurements and previous knowledge to yield a trustworthy picture of the present situation. Analysis based on a limited number of observations, sometimes called a 'nowcast' and calculation of the probable future state, the 'forecast', are goals of operational REA also in well known parts of the ocean.

Analysis maps of the atmosphere and weather forecasts based on a worldwide observational network are standard meteorological products. A comparable permanent observational network for the ocean does not exist, mainly because of different requirements for station spacing. Mesoscale eddies in the ocean, from the underlying physics comparable with large low-pressure domains in the atmosphere, have scales of only a few tens of kilometres. Continuous observations covering large ocean areas are not affordable on these scales. Information obtained by satellite remote sensing suffers from the opaqueness of sea water to electromagnetic waves, so that the state of the interior ocean can only be assessed by its surface properties. From local vertical displacements of the sea surface, ocean circulation patterns of hundreds of kilometre size have been derived. To obtain smaller scale circulations, the satellite altimeter accuracy of few centimetres is insufficient and satellite track spacing too wide. At-sea measurements or air-deployed sondes are essential for an observational network for smaller scale oceanography. To set up a regional network for near real-time analysis and ocean forecast is a typical REA task, whether in a well known exercise area or in an unfamiliar region.

Practising operational REA without supporting an actual naval exercise is also a good idea. Being disconnected from military operations, REA planners would be free to define an area where environmental information is lacking. In this respect it would be equivalent to the old type of MILOC surveys. But by exercising REA with all its fast data processing, specific communications and product generation mechanisms, we avoid the old disadvantage of lack of interest in the finally distributed results. The SACLANT Undersea Research Centre is, in the bounds of its possibility, offering expertise and tools for joint projects of multilateral REA. The primary goal in the Centre's REA thrust area is, however, the development of new REA methodologies rather than exercise support.

Typical research tools often do not meet the requirements of REA. New deployable instruments being developed for REA must deliver measurements close to real-time rather than store data internally until the instrument is recovered. Cellular telephone technology, very soon offering world wide connectivity via low orbiting satellites, is used for efficient and inexpensive data transfer. Instruments under development are a low cost air-deployable moored oceanographic sensor, a trawl-safe bottom deployed property and current profiler regularly transmitting *via* a pop-up antenna, sensor packages for unmanned underwater vehicles and GPS-tracked sonobuoys for the measurement of bottom properties *via* acoustical inversion. REA methodologies such as broadband acoustical inversion, ambient noise modelling, real time ocean analysis and interpretation of remotely sensed features, are ongoing research topics. In addition and apart from normal research, the collection, modification and final distribution of REA data and the estimation of the value gained by REA are fields of investigation by themselves.

4 Rapid Response

A series of MILOC surveys in and at the entrance to the Mediterranean Sea (Fig. 2) has taken place in three consecutive years. They were connected with the naval exercises Dynamic Mix in 1996 and 97 and with Strong Resolve in 1998. Up to 8 ships, 6 patrol aircraft and numerous institutions have been active in REA. In an impressive collaborative effort, they have demonstrated their skills in data acquisition and immediate processing, in data fusion and assimilation into models, in data reduction and description of the findings. Even though Rapid Response was tied to naval exercises, one basic ingredient of operational REA was not met. Rapid Response was intentionally not restricted merely to satisfying the requirements of operational commanders. Instead, all contributions were happily accepted, none rejected. Rapid Response was intended and carried out as an REA demonstration, a showcase of products made available to navy operations by the survey and research communities.

Earlier MILOC surveys have concentrated on environmental data collection for anti-submarine warfare. Rapid Response surveys also included amphibious and mine warfare related measurement programmes. With the ships and aircraft provided by Canada, France, Germany, Greece, Italy, the Netherlands, Spain, Turkey, the United Kingdom and the United States, it was possible to cover the wide spectrum of survey tasks. Research Institutes from the same countries participated actively and delivered results from satellite remote sensing, survey data fusion or survey-specific numerical modelling.

Rapid Response contributions were produced and submitted in nearly hundred different formats and grades of complexity: simple measurements or photographs, time series or spatial profiles, maps or satellite images, reports or composite products. All REA contributions were required in electronic format, readable with standard computer software. The data fusion centre was located on the NATO Research Vessel *Alliance* and at the SACLANT Undersea Research Centre. In the first year, the final products consisted of environmental guides, printed within one week after completion of the ocean survey. In 1997 and 98, the Rapid Response web server held all information including derived products. The Internet that was used as the main data communications network, was accessible by most land based institutions and by the main customer on the naval exercise command ship. NRV *Alliance* was the only ship among survey participants that had a high bandwidth Inmarsat B satellite link to her home institute. Rapid Response web servers on *Alliance* and at the Centre exchanged updates two times every day, so that the same contents were available on *Alliance* and for participants connecting through the Internet. Two of the other survey ships had low bandwidth satellite connections that were sufficient for the delivery of their contributions but not for uploading massive data provided by others. Close to shore, cellular telephones were used by survey ships to transfer data to the fusion centre, again with limited data rates. For moderately fast direct connections between the server on *Alliance* and the other ships, radios were installed, the

performance of which was not fully convincing. (In May 1999, a spread spectrum ISDN quality radio link was used with great success between *Alliance* and an Italian navy tug). Rapid Response proved that commercial off-the-shelf solutions for communications and data fusion are appropriate for rapid navy support. The weakest links in the REA communications chain are the channels for transfer of results to navy commanders.

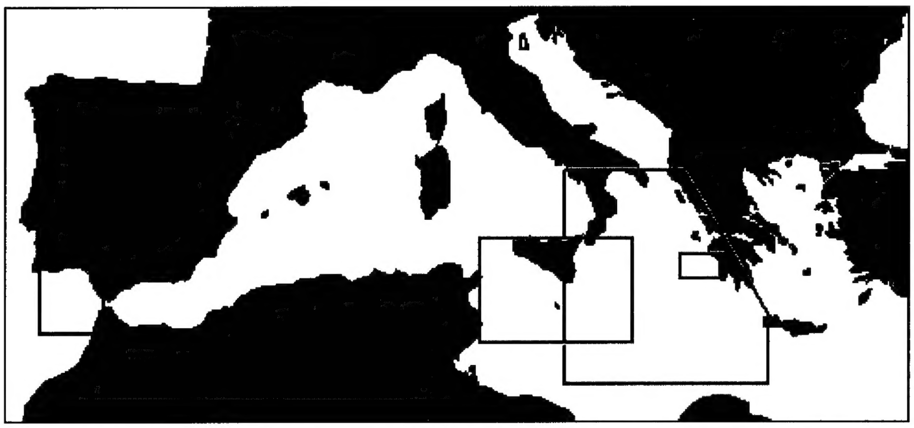


Figure 2 *Rapid Response survey areas in 1996 (Sicilian Channel, 1997 (Ionian, Northern Adriatic and Northeastern Aegean Seas) and 1998 (Gulf of Cadiz).*

Rapid Response as a demonstration of capabilities has shown to navy commanders what at present is possible to achieve in REA. It provided scientists and the MILOC community with the necessary suggestions on how to proceed with REA research and organization structures, before they initiate another REA demonstration of similar size in a couple of years.

References

Pouliquen, E., Kirwan, A.D., Pearson, R.T. – editors. Rapid Environmental Assessment, Proceedings of a conference held in Lerici (SP), Italy, 10-14 March 1997 SACLANTCEN Conference Proceedings CP-44, 290 pages. [ISBN 88-900 194-0-9].

Oceanology International 98, The Global Ocean, 10-13 March 1998, Brighton, UK, Conference Proceedings Vol. 2, Rapid Environmental Assessment Technology, 382 pages. [ISBN 0 900254 21 1].

Sellschopp, J. Experience gained and lessons learnt in three years of Rapid Response. UDT 1998, 23-25 June 1998 in London, Conference Proceedings, pp 69-73.

Sellschopp, J. Rapid Environmental Assessment. Naval Forces, International Forum for Maritime Power, Vol. XX, No. III, June 1999, pp. 110-115.

Sellschopp, J. (editor). MILOC Survey Rapid Response 98 Data and Products. SACLANTCEN CD-2, 1998.

Sellschopp, J., Trangeled, A., Zahorodny, M. *Rapid Response 96 & 97, MILOC Surveys for Rapid Environmental Assessment.* SACLANTCEN CD-19, 1998.

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